Studies of trends in salinity indicators in New Jersey Streams

Robert G Reiser
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USGS
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Trends in water quality in New Jersey Streams from 1976-86

- Study in cooperation with NJDEP,

86 sites monitored from 1980-86,

67 from 1976-86

- 80 ASWQMN, 5 NASQAN , 1 Hydrologic Benchmark site
- Tests run on 7 and 11 year periods
- 49 parameters studied including SC, Cl, Na, and sum of Dissolved solids
- Methods
  - Seasonal Kendal Test
  - Censored Data Regression - maximum likelihood methods
  - Flow adjusted concentrations – least squares regression
  - Significance level at <0.10

Para meter	Number of stations with significant trends			
	1976-86		1980-86	
	Increase	Decrease	Increase	Decrease
Cl	49	2	57	0
Na	39	3	32	1
SC	22	5	22	2
DS	0	0	16	0

DS – sum: Not computed if components were missing or censored 1980-86: 50 sites , 1976-86: 3 sites tested

Water Resources Investigation Report 90-4046 by Hay and Campbell
https://pubs.er.usgs.gov/publication/wri904046

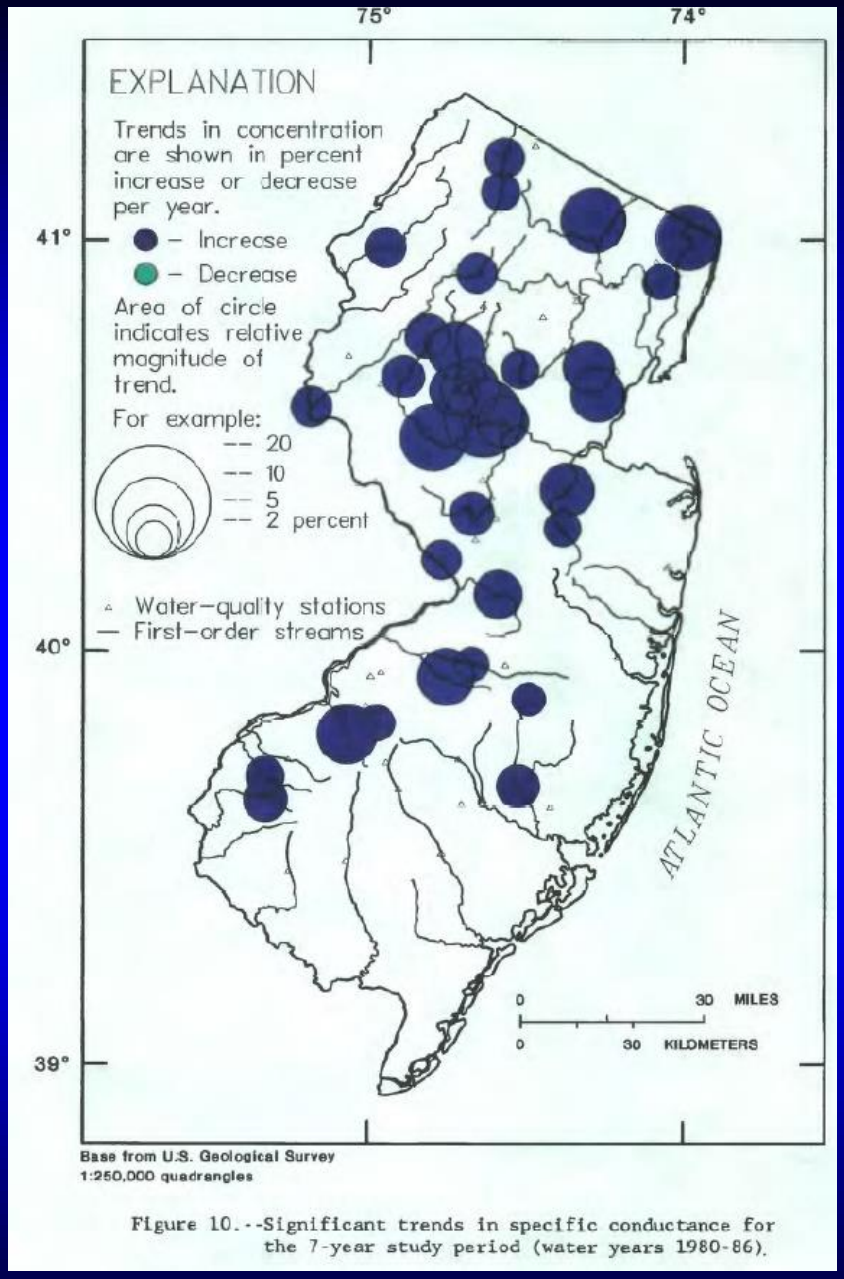


Figure 10.--Significant trends in specific conductance for the 7-year study period (water years 1980-86).

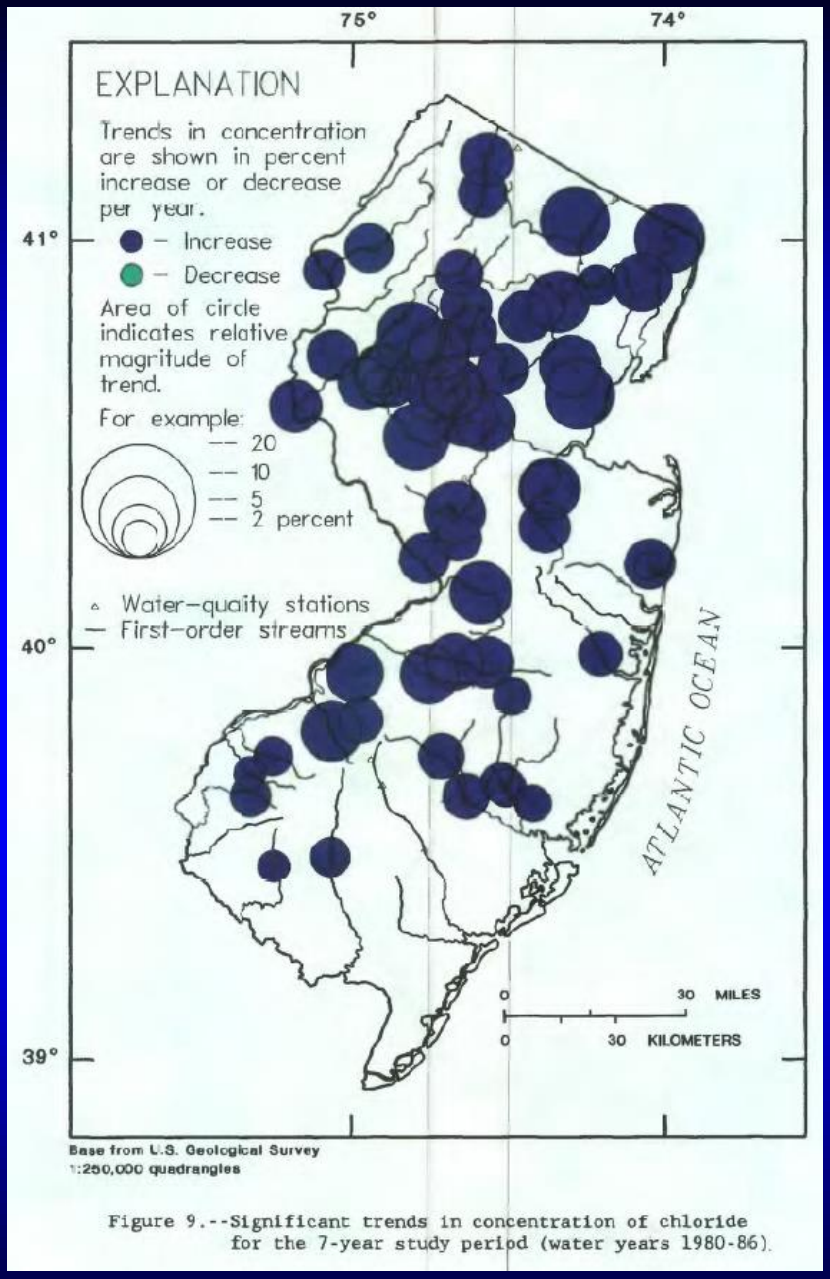


Figure 9.--Significant trends in concentration of chloride for the 7-year study period (water years 1980-86).

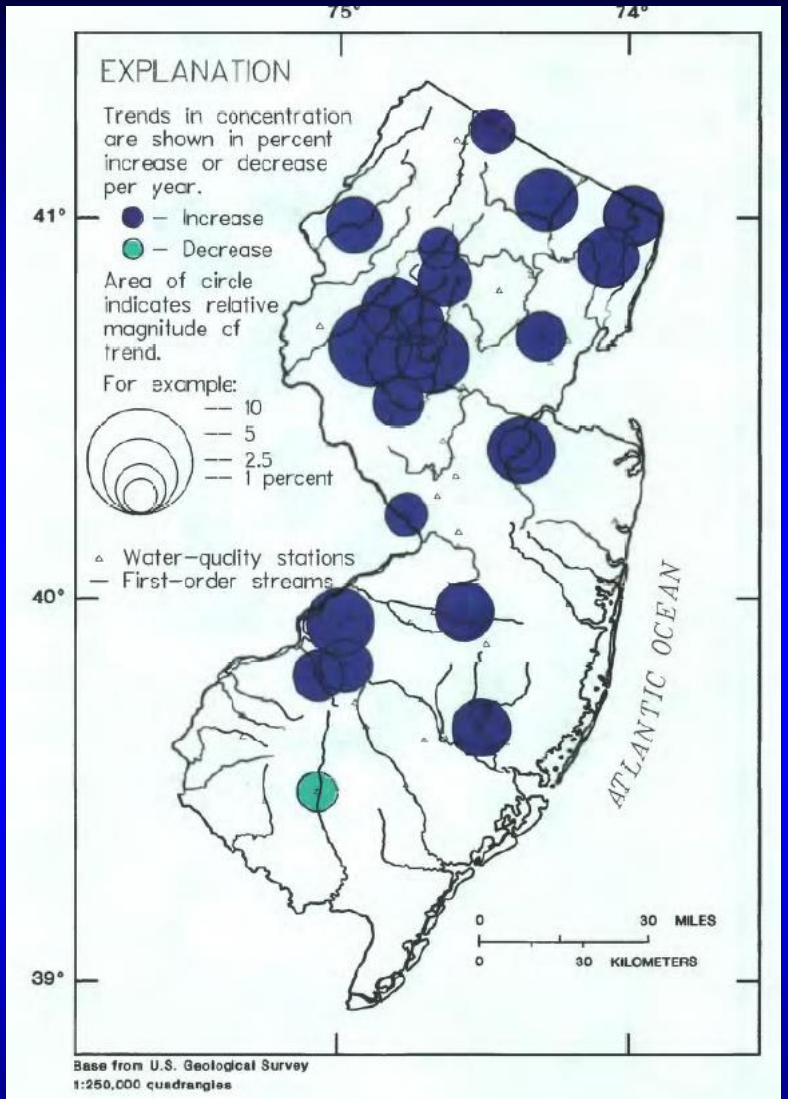


Figure 8.--Significant trends in concentration of dissolved sodium for the 7-year study period (water years 1980-86).

Trends in water quality in New Jersey Streams from 1986-95

- Study in cooperation with NJDEP,
- 83 sites monitored from 1986-95, 77 ASWQMN, 5 NASQAN , 1 Hydrologic Benchmark site
- 24 parameters studied including SC, Cl, Na, and Dissolved solids sum
- Methods
  - Seasonal Kendal Test
  - Tobit regression (censored data)
  - Flow adjusted – Lowess Curve & unadjusted concentrations tested
  - < 0.10 level of significance

Some Discussion about effects upgrades to point sources and changes in land use have on water quality trends

Parameter	Trend results by number of stations			
	Flow Adjusted Concentrations			
	Positive	Negative	None	Not Tested
Cl	29	3	33	18
SC	24	2	55	2
Na	26	2	37	18
DS	24	2	35	22

Water Resources Investigation Report 98-4204 by Hickman and Barringer https://pubs.er.usgs.gov/publication/wri984204

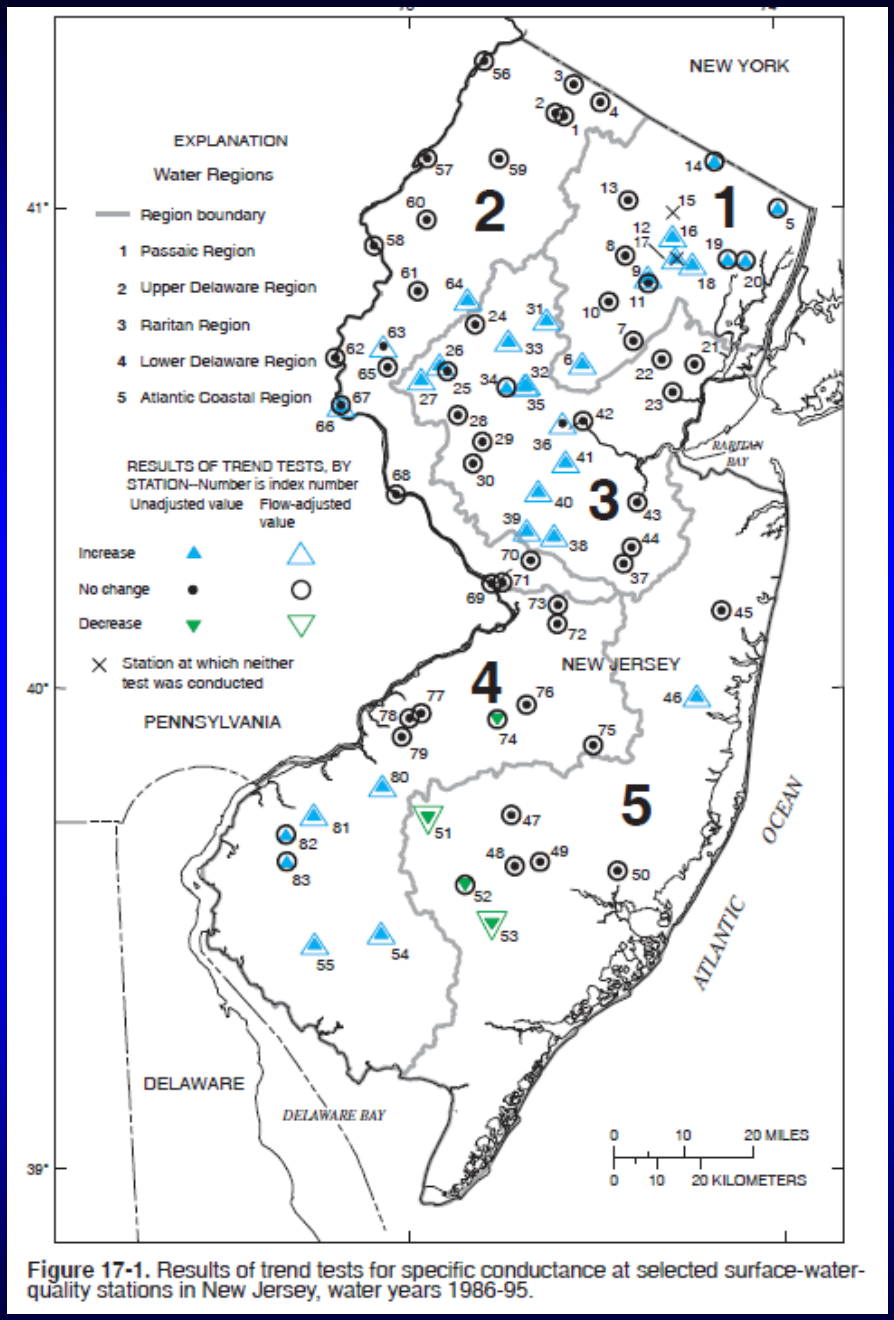


Figure 17-1. Results of trend tests for specific conductance at selected surface-water-quality stations in New Jersey, water years 1986-95.

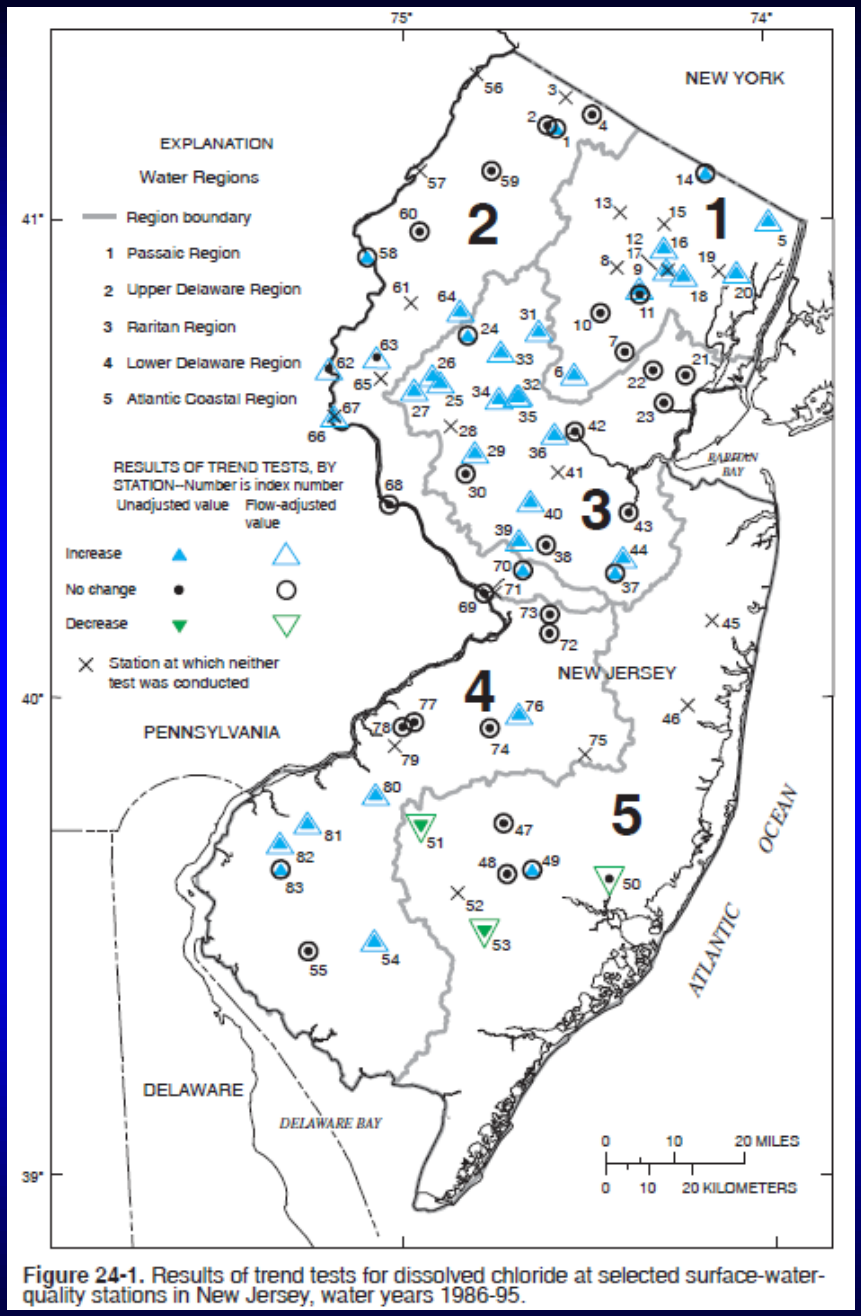


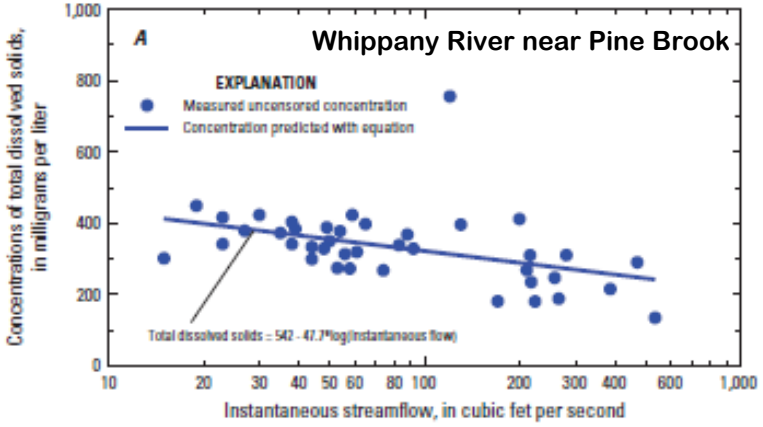
Figure 24-1. Results of trend tests for dissolved chloride at selected surface-water-quality stations in New Jersey, water years 1986-95.

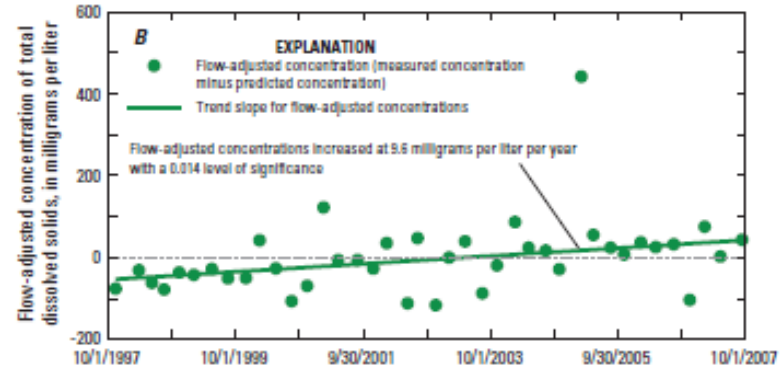
Trends in water quality in New Jersey Streams from 1998-2007

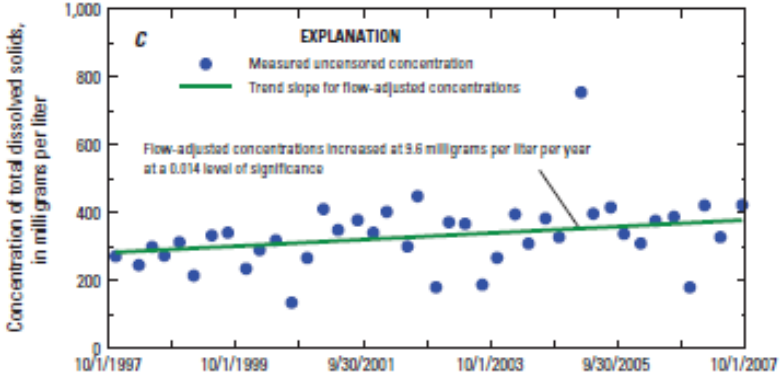
- Study in cooperation with NJDEP,
- 70 sites monitored from 1998-2007, 69 ASWQMN, 1 ASWQMN/HBN, & 1 DRBC/NAWQA
- 6 parameters studied including Total Dissolved solids
- Methods
  - Seaaonal Kendal Test
  - Tobit regression (censored data)
  - Flow adjusted – Lowess Curve & unadjusted trends tested
  - < 0.05 level of significance
  - Summary statistics

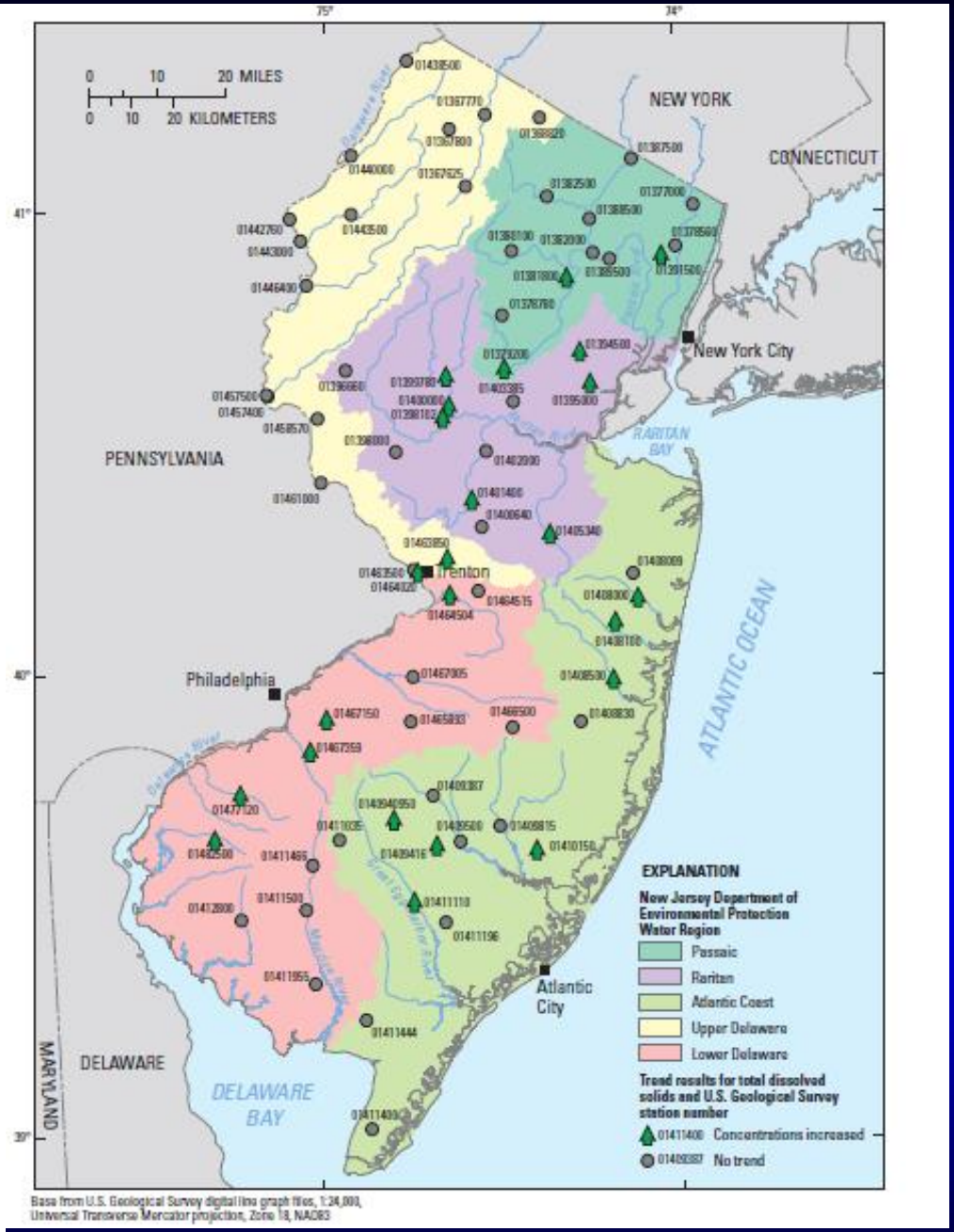
Parameter	Trend results by number of stations	
	Flow Adjusted Concentrations	
	Increase	Decrease
TDS	24	0

Science Investigative Report 2010-5088 Hickman and Gray
https://pubs.er.usgs.gov/publication/sir20105088


A
Whippany River near Pine Brook
EXPLANATION
Measured uncensored concentration
Concentration predicted with equation
Total dissolved solids = 542 - 47.7*log(instantaneous flow)
Concentrations of total dissolved solids, in milligrams per liter
Instantaneous streamflow, in cubic fet per second


B
EXPLANATION
Flow-adjusted concentration (measured concentration minus predicted concentration)
Trend slope for flow-adjusted concentrations
Flow-adjusted concentrations increased at 9.6 milligrams per liter per year with a 0.014 level of significance
Flow-adjusted concentration of total dissolved solids, in milligrams per liter


C
EXPLANATION
Measured uncensored concentration
Trend slope for flow-adjusted concentrations
Flow-adjusted concentrations increased at 9.6 milligrams per liter per year at a 0.014 level of significance
Concentration of total dissolved solids, in milligrams per liter


NEW YORK
CONNECTICUT
PENNSYLVANIA
DELAWARE
MARYLAND
New York City
Trenton
Philadelphia
Atlantic City
ATLANTIC OCEAN
RARITAN BAY
DELAWARE BAY
EXPLANATION
New Jersey Department of Environmental Protection Water Region
Passaic
Raritan
Atlantic Coast
Upper Delaware
Lower Delaware
Trend results for total dissolved solids and U.S. Geological Survey station number
Concentrations increased
No trend

Variations in statewide water quality of NJ streams 1998-2009

- Study in cooperation with NJDEP,
- ASWQMN redesigned in 1998 to include 42 state-wide status sites
- 371 sites in 8 groups of state-wide status monitored from 1998-2009
- 6 background sites 2001-09, 4 from 1998-2000
- 6 parameters studied including TDS year-round & Cl January - March
- Methods
  - Kruskal Wallis Test
  - Tukey's Multiple Comparison Test
  - Mann Whitney test
  - <0.05 level of significance

Table 4. Results of statistical tests to determine whether constituent concentrations differ among years at selected Statewide Status stations in New Jersey, water years 1998–2009.

[A, B, C, differing letters indicate significant differences in mean values, according to the Tukey multiple-comparison test]

	Kruskal-Wallis		Tukey's Test				Kruskal-Wallis		Tukey's Test		
Water year(s)	Significance level achieved	[1]Ho	A	B	C	Water year(s)	Significance level achieved	[1]Ho	A	B	C
Total dissolved solids						Dissolved phosphorus					
1998				B		1998					
1999				B		1999					
2000				B		2000					
2001–02	0.000	Reject	A	B		2001–02	0.059	Accept			
2003–04			A	B		2003–04					
2005–06			A	B		2005–06					
2007–08			A	B		2007–08					
2009				B		2009					
Dissolved chloride						Total phosphorus					
1998				B		1998				B	
1999			A	B		1999			A	B	
2000			A	B		2000			A	B	
2001–02	0.000	Reject	A	B		2001–02	0.023	Reject	A		
2003–04			A	B		2003–04			A	B	
2005–06			A	B		2005–06			A		
2007–08			A	B		2007–08			A	B	
2009			A	B		2009			A	B	
Dissolved nitrite + nitrate						Total nitrogen					
1998					C	1998				B	
1999			A	B	C	1999			A	B	
2000				B	C	2000			A	B	
2001–02	0.000	Reject		B	C	2001–02	0.000	Reject	A	B	
2003–04			A			2003–04			A		
2005–06			A	B		2005–06			A		
2007–08			A			2007–08			A		
2009					C	2009			A	B	

[1]Ho, Null hypothesis: no difference in median concentrations among years.

Science Investigative Report 2012-5047, Heckathorn and Deetz
https://pubs.er.usgs.gov/publication/sir20125047

Variations in statewide water quality of NJ streams 1998-2009

- Median concentrations of TDS and Chloride at the Statewide status sites increased significantly from 1998-2008
- Median concentrations of TDS and Chloride did not significantly increase at background sites from 1998 – 2008
- A drought occurred in 2002, the year with highest concentrations at many sites

Trends in water quality in New Jersey Streams from 1971-2011

- Study in cooperation with NJDEP & DRBC, - concentrations and loads
- 28 sites: 27 ASWQMN, 1 DRBC/NAWQA
- 3 nutrients at all sites and SC, TDS,and Cl at 4 sites
- Methods
  - Weighted Regressions on Time Discharge and Season (WRTDS)
  - Seasonal Rank Sum Test
    - Flow adjusted data – Lowess Curve
  - < 0.05 level of significance
- Annual concentrations and fluxes
- Trends for each decade from 1970's to 2000's & 1980-2011

Parameter	**Number of stations tested**	**Number of stations Results from 1980-2011**		
		Upward	Down-ward	No trend
SC	4	4	0	0
Cl	4	4	0	0
TDS	4	4	0	0

Upward trends in both Concentration and Flux

SIR 2016-5176 Hickman and Hirsch
https://pubs.er.usgs.gov/publication/sir20165176

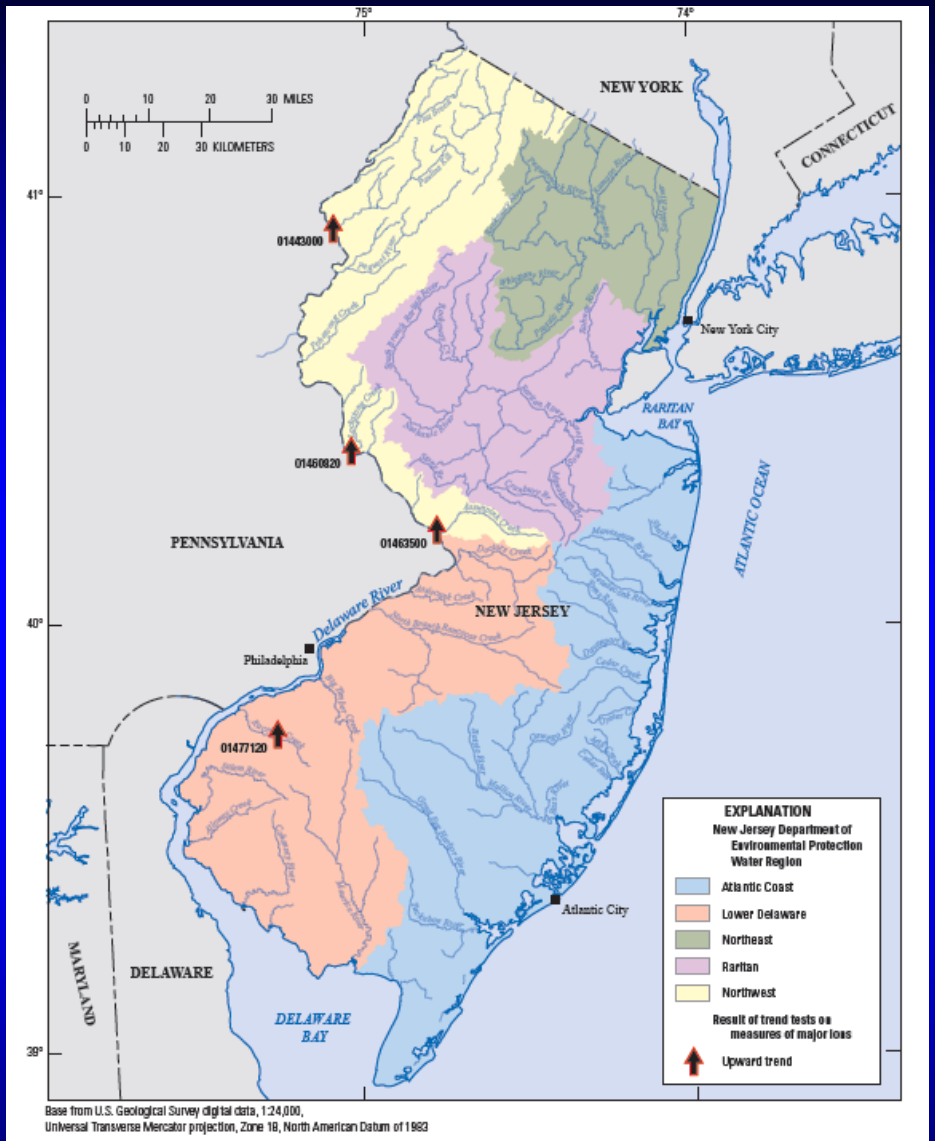


Figure 12. Combined results of trend tests on measures of major ions at water-quality stations on streams in New Jersey, water years 1980–2011.

Chloride in Streams & Groundwater underlain by Glacial Aquifer System in Northern USA 1988-2004

9 stream sites in NJ : Data 1991 - 2004

Passaic River near Chatham,NJ

Rockaway River above reservoir at Boonton, NJ

Whippany River at Morristown, NJ

Whippany River near Pine Brook, NJ

Saddle River at Ridgewood, NJ

Saddle River at Lodi

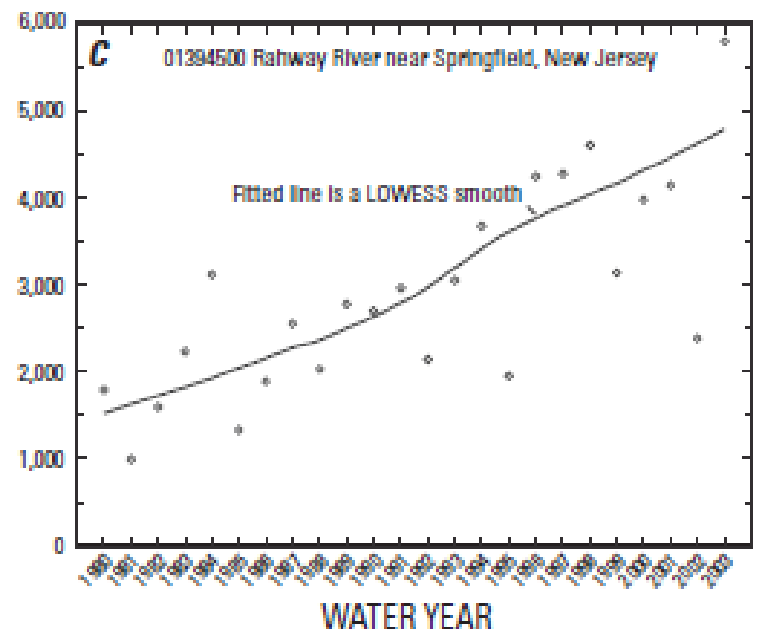
Rahway River near Springfield

Flat Brook near Flatbrookville, NJ

Paulins Kill at Blairstown, NJ

Concentrations exceeded 230 mg/l in some samples from December through April at Lodi and Springfield

Chloride Load in tons per year



https://pubs.usgs.gov/sir/2009/5086/

Study of Chloride Levels in Streams & Aquifers in Northern USA 1988-2004

Annual median chloride yields from 95 watersheds grouped by landuse

Urban: 88 tons/sq mi

Agriculture: 15.4

Forested: 6.4

Relation of Chloride Yield to Explanatory Variables

69% of variability explained by

1) Highway density

2) Major Point Source discharges upstream

3) Potential Evapotranspiration

4) Urban – Agricultural Land Use

- Sources of chloride in groundwater identified by the relation of chloride concentration to chloride:bromide ratio by mass

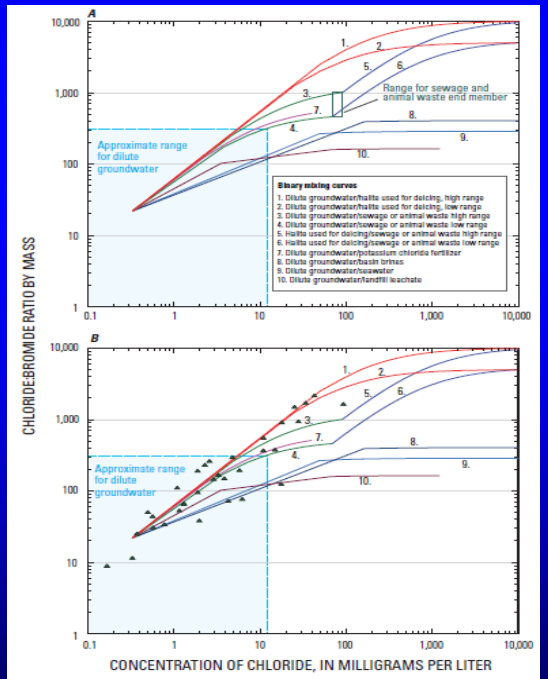


Figure 9. *(A)* Binary mixing curves representing sources of chloride. The relation of chloride concentration to chloride:bromide ratios (by mass) for samples from shallow monitoring wells in *(B)* forested areas, *(C)* agricultural areas, and *(D)* urban areas.